U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 127.

IMPORTANT INSECTICIDES:

DIRECTIONS FOR THEIR PREPARATION AND USE.

[A Revision of Farmers' Bulletin No. 19.]

BY

C. L. MARLATT, M. S.,
FIRST ASSISTANT ENTOMOLOGIST.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., February 6, 1901.

SIR: I have the honor to transmit herewith copy for a Farmers' Bulletin on insecticides. This bulletin will supplant Farmers' Bulletin, No. 19, prepared in 1894, under my direction, by Mr. C. L. Marlatt, first assistant entomologist. The latter publication has gone through four slightly revised editions, but has now been thoroughly revised and in large part rewritten by Mr. Marlatt, and considerable new matter has been added. I therefore recommend that it be reissued under a new number, to take the place of the older publication. The constant call for information on insecticides warrants the prompt publication of this bulletin in a large edition.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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IMPORTANT INSECTICIDES: DIRECTIONS FOR THEIR PREPARATION AND USE.

INTRODUCTORY.

Without going minutely into the field of remedies and preventives for insect depredators, it is proposed to give in this bulletin brief directions concerning a few of the insecticide agents having the widest range and attended with the greatest usefulness, economy, and ease of application. These are not covered by patent, and in general it is true that the patented articles are inferior, and many of the better of them are in fact merely more or less close imitations of the standard substances and compounds hereinafter described. Only such brief references to food and other habits of the insects covered will be included as are necessary to illustrate the principles underlying the use of the several insecticide agents recommended.

RELATION OF FOOD HABITS TO REMEDIES.

For the intelligent and practical employment of insecticides it is necessary to comprehend the nature and method of injury commonly due to insects. Omitting for the present purpose the many special cases of injury which necessitate peculiar methods of treatment, the great mass of the harm to growing plants from the attacks of insects falls under two principal heads based on distinct principles of food economy of insects, viz, whether they are biting (mandibulate) or sucking (haustellate), each group involving a special system of treatment.

INJURY FROM BITING INSECTS.

The biting or gnawing insects are those which actually masticate and swallow some portion of the solid substance of the plant, as the wood, bark, leaves, flowers, or fruit. They include the majority of the injurious larvæ, many beetles, and the locusts. (See fig. 1.)

For these insects direct poisons, such as the arsenicals, which may be safely applied to the leaves or other parts of the plant attacked,

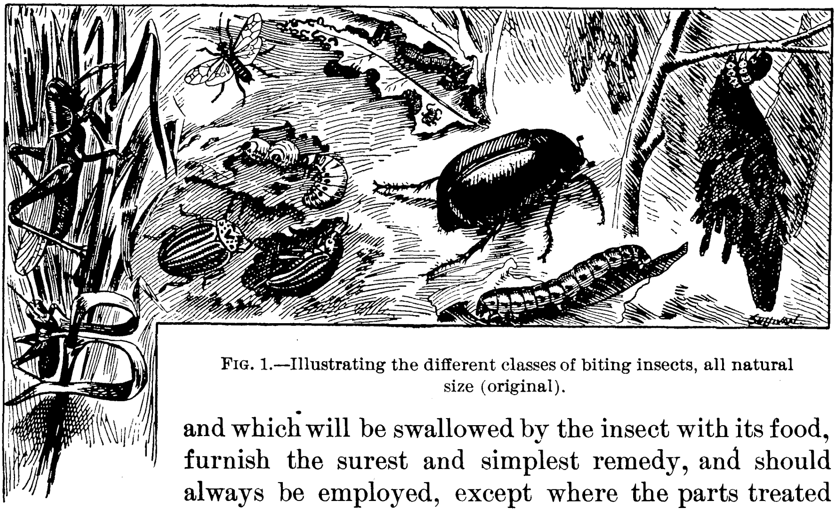

FIG. 1.—Illustrating the different classes of biting insects, all natural size (original).

and which will be swallowed by the insect with its food, furnish the surest and simplest remedy, and should always be employed, except where the parts treated are themselves to be shortly used for the food of other animals or of man.

INJURY FROM SUCKING INSECTS.

The sucking insects are those which injure plants by the gradual extraction of the juices, either from the bark, leaves, or fruit, and include the plant-bugs, plant-lice, scale insects, thrips, and plant-feeding mites. These insects possess, instead of biting jaws, sucking beaks or bristles, which are thrust down through the outer layers of the bark

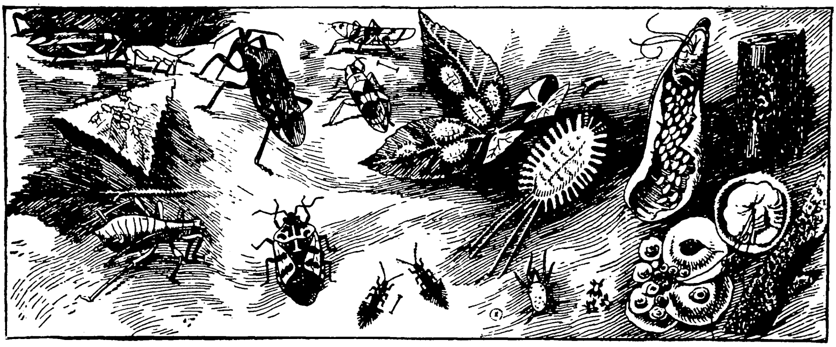

FIG. 2.—Illustrating the different classes of sucking insects, natural size and enlarged (original).

or leaves into the soft, succulent tissues beneath and used to extract the plant juices, with a resulting injury not so noticeable as in the first group, but not less serious. (See fig. 2.)

For this class of insects the application of poisons, which penetrate little, if at all, into the plant cells, is of trifling value, and it is neces-

sary to use substances which will act externally on the bodies of these insects, either as a caustic or to smother or stifle them by closing their breathing pores, or to fill the air about them with poisonous fumes. Of value also as repellants are various deterrent or obnoxious substances.

Wherever it is not desirable to use poisons for biting insects, some of the means just enumerated will often be available.

GROUPS SUBJECT TO SPECIAL TREATMENT.

The general grouping outlined above relates to the species which live and feed upon the exterior of plants for some portion or all of their lives, and includes the great majority of the injurious species. Certain insects, however, owing to peculiarities of habit, inaccessibility, or other causes, require special methods of treatment. Of these, two groups properly come within the scope of this bulletin: (1) Those working beneath the soil, or subterranean insects, such as the white grubs, root maggots, root-lice, etc., and (2) insects affecting stored products, as various grain and flour pests.

Three other groups, which include species requiring very diverse methods of treatment, and therefore not coming within the limits of this bulletin, are (1) the internal feeders, such as wood, bark, and stem borers, leaf-miners, gall insects, and species living within fruits; (2) household pests, and (3) animal parasites.

The classification of insects outlined above, based on mode of nourishment and indicating groups amenable to similar remedial treatment, simply stated, is as follows:

I. External feeders:
   (*a*) Biting insects.
   (*b*) Sucking insects.
II. Internal feeders.
III. Subterranean insects.
IV. Insects affecting stored products.
V. Household pests.
VI. Animal parasites.

INSECTICIDES FOR EXTERNAL BITING INSECTS (FOOD POISONS).

THE ARSENICALS: PARIS GREEN, SCHEELE'S GREEN, ARSENATE OF LEAD, AND LONDON PURPLE.

The arsenical compounds have supplanted, practically, all other substances for the insects falling under this heading.[1] The two arsenicals in most common use, and obtainable everywhere, are Paris green and London purple. The other two arsenicals mentioned, viz, Scheele's

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[1] *Hellebore.*—The powdered roots of the white hellebore (*Veratrum viride*) are often recommended and used as an insecticide, particularly as a substitute for the arsenites. This substance is useful when a few plants only are to be sprayed, as in yards and

green and arsenate of lead, are less known and not so easily obtainable, but in some respects are better than the first-mentioned poisons, as will be shown later. The use of powdered white arsenic is not recommended, on account of its great liability to scald foliage, as well as for the fact that it is apt to be mistaken for harmless substances. The arsenicals mentioned have the following characteristics:

Paris green is a definite chemical compound of arsenic, copper, and acetic acid (known as the aceto-arsenite of copper), and should have a nearly uniform composition. It is a rather coarse powder, or, more properly speaking, crystal, and settles rapidly in water, which is its greatest fault. Its excessive cost, about 20 cents a pound, is due to its being crystallized with acetic acid, making it a more brilliant pigment, but giving it a coarse grain and rendering it a much poorer insecticide.

Scheele's green is similar to Paris green in color, and differs from it only in lacking acetic acid; in other words, it is a simple arsenite of copper. It is a much finer powder than Paris green, and therefore more easily kept in suspension, and has the additional advantage of costing only about half as much per pound. When properly washed and prepared by the manufacturers it is less harmful to foliage even than Paris green, is quicker in effect, and should supplant the latter as an insecticide. It is used in the same way and at about the same strength as Paris green and London purple.

London purple is a waste product in the manufacture of aniline dyes and contains a number of substances, chief of which are arsenic and lime. It is quite variable in the amount of arsenic and is not so effective as the green poisons and is much more apt to scald unless mixed with lime. It comes as a very fine powder, and is more easily kept in suspension than Paris green. It costs about 10 cents a pound.

Arsenate of lead is prepared by combining, approximately, 3 parts of the arsenate of soda with 7 parts of the acetate of lead (white sugar of lead) in water. These substances when pulverized unite readily and form a white precipitate, which is more easily kept suspended in water than any of the other poisons. Bought wholesale, the crystallized acetate of lead costs about 7¼ cents a pound (or the uncrystallized brown sugar of lead, 5 cents), and the arsenate of soda 5 cents a pound.

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small gardens, but is too expensive for large operations. It kills insects in the same way as the arsenicals, as an internal poison, and is less dangerous to man and the higher animals; but if sufficient be taken it will cause death. It is particularly effective against the larvæ of sawflies, such as the cherry slug, rose slug, currant worms, and strawberry worms.

It may be applied as a dry powder, preferably diluted with from 5 to 10 parts of flour, and dusted on the plants through a muslin bag or with powder bellows. The application should be made in the evening, when the plants are moist with dew. Used as a wet application, it should be mixed with water in the proportion of 1 ounce to the gallon of water and applied as a spray.

It is now on the market as a dry powder, white or colored with a dye, ready for immediate use, costing about 10 cents a pound, and also in paste form. Arsenate of lead may be used at any strength from 3 to 15 pounds to the 100 gallons of water without injury to the foliage, and in this respect is much safer on delicate plants than any other arsenical. Its use is advised where excessive strengths are desirable or with delicate plants where scalding is otherwise liable to result. With this insecticide there is an advantage in using the freshly prepared and wet mixture in that it gives a more filmy and adhering coating to foliage, the same fineness not being secured when it has been dried and repulverized.

In point of solubility and corresponding danger of scalding the foliage these arsenicals fall in the following order, the least soluble first: Arsenate of lead, Scheele's green, Paris green, and London purple. The difference between the first three is not great in the particulars noted nor also in point of effectiveness against larvæ or other insects. London purple is ordinarily considerably less effective.

HOW TO APPLY ARSENICALS.

There are three principal methods of applying arsenicals. The wet method, which consists in using these poisons in water in the form of spray, is the standard means, secures uniform results at least expense, and is the only practical method of protecting fruit and shade trees. The dry application of these poisons in the form of a powder, which is dusted over plants, is more popular as a means against the cotton worm in the South, where the rapidity of treatment possible by this method, and its cheapness, give it a value against this insect, in the practical treatment of which prompt and economical action are the essentials. This method is also feasible for any low-growing crop, such as the potato, young cabbages, or other plants not to be immediately employed as food. The third method consists in the use of the arsenicals in the form of poisoned baits, and is particularly available for such insects as cutworms, wireworms, and locusts in local invasions.

The wet method.—Either Scheele's green, Paris green, or London purple may be used at the rate of 1 pound to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The stronger mixtures are for such vigorous foliage as that of the potato for the Colorado potato-beetle, and the greater dilutions for the more tender foliage of the peach or plum. An average of 1 pound to 150 gallons of water is a good strength for general purposes. The poison should be first made into a thin paste in a small quantity of water and quicklime added in amount equal to the poison used to take up the free arsenic and remove or lessen the danger of scalding. An excess of lime will do no injury. The poisons thus mixed should be strained into the spray

tank or reservoir, care being taken that all the poison is pulverized and washed through the meshes of the strainer. The use of the lime is especially desirable in the case of the peach and plum, the foliage of which, particularly the former, is very tender and easily scalded. To the stronger foliage of the apple and most shade trees Paris green may be applied without danger at the strength of 1 pound to 150 gallons of water; with London purple it is always better to use the lime.

The arsenate of lead is prepared by carefully pulverizing and combining, in a small quantity of water, the weight of the two ingredients needed at the strength decided upon as indicated by the capacity of the spray tank. The chemical combination is effected in a few minutes and the resulting milky mixture is ready for the tank. Lime is not needed with this arsenical.

If it be desirable to apply a fungicide at the same time, as on the apple for the codling moth and the apple scab fungus, the Bordeaux mixture[1] may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic and makes it an excellent medium for the arsenical, removing, as it does, all liability of scalding the foliage and enabling an application of the arsenical, if necessary, eight or ten times as strong as it could be employed with water alone.

The arsenicals cannot be safely used with most other fungicides, such as the sulphate of copper, eau celeste or iron chloride solution, the scalding effects of these being greatly intensified in the mixture.

The dry method.—The following description applies to the pole-and-bag duster commonly used against the cotton worm: A pole 5 to 8 feet long and about 2 inches in diameter is taken, and a three-fourths inch hole bored through it within six inches of each end. Near each end is securely tacked a bag of "8-ounce osnaburg cloth," 1 foot wide and

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[1] *Bordeaux mixture formula.*—Into a 50-gallon barrel pour 30 gallons of water, and suspend in it six pounds of bluestone in coarse sacking. Slack 4 pounds of fresh lime in another vessel, adding water slowly to obtain a creamy liquid, free from grit. When the bluestone is dissolved add the lime milk slowly with water enough to fill the barrel, stirring constantly.

With insufficient lime the mixture sometimes injures the foliage, and it should be tested with a solution obtained by dissolving an ounce of yellow prussiate of potash (potassium ferrocyanide) in one-half pint of water. If there be insufficient lime in the Bordeaux mixture the addition of a drop or two of this solution will cause a brownish-red color, and more lime should be added until no change takes place when the solution is dropped in. Use the Bordeaux mixture promptly, as it deteriorates on standing.

Stock solutions of both the bluestone and lime may be kept for any length of time. Make the stock bluestone by dissolving in water at the rate of 2 pounds to the gallon. The stock lime is slacked and kept as a thick paste. Cover both mixtures, to prevent evaporation and keep the lime moist. For the 50-gallon formula add 3 gallons of the bluestone solution to 50 gallons of water, and introduce the stock lime slowly until there is no reaction with the testing solution.—GALLOWAY.

18 inches to 2 feet long, so that the powdered poison may be introduced into the bags with a funnel through the holes at the ends of the pole. The bags are filled with undiluted Paris green, which is generally preferred to London purple on account of its quicker action, and the apparatus is carried on horse or mule back, through the cotton fields, dusting two or four rows at once. The shaking induced by the motion of the animal going at a brisk walk or at a trot is sufficient to dust the plants thoroughly, or the pole may be jarred by hand. The application is preferably made in early morning or late evening, when the dew is on, to cause the poison to adhere better to the foliage.

From 1 to 2 pounds are required to the acre, and from 10 to 20 acres are covered in a day. The occurrence of heavy rains may necessitate a second application, but frequently one will suffice. This simple apparatus, on account of its effectiveness and cheapness, is employed throughout the cotton belt to the general exclusion of more complicated and expensive machinery. The cost frequently does not exceed 25 cents per acre, and the results are so satisfactory that the leaf worm is no longer considered a serious factor in cotton culture.

With the patented air-blast machines for the dry distribution of poisons, arsenicals are diluted with 10 parts of flour, lime, or ground gypsum, and from 60 to 75 acres may be covered in a day by using relays of men and teams. Greater uniformity is secured with these machines in distribution of the poisons, but their cost (from $30 to $60) prevents their general use.

The planter should have a good supply of poison on hand and apparatus for its application prepared in advance, since when the worm puts in an appearance its progress is very rapid, and a delay of a single day may result in material damage to the crop.

If small garden patches are dusted with poison by this or similar means from bags or with hand bellows, it is advisable always to dilute the poison with 10 parts of flour, or preferably lime, and for application to vegetables which will ultimately be used for food, as the cabbage, 1 ounce of the poison should be mixed with 6 pounds of flour or 10 of lime and dusted merely enough to show evenly over the surface. Arsenicals should not be applied to lettuce or other vegetables the free leafage of which is eaten.

As poisoned bait.—It is not always advisable or effective to apply arsenicals directly to the plants, and this is particularly true in the case of the attacks of the grasshopper and of the various cutworms and wireworms. In such cases the use of poisoned bait has proved very satisfactory.

For locusts, take 1 part, by weight, of white arsenic, 1 of sugar, and 6 of bran, to which add water to make a wet mash. Place a tablespoonful of this at the base of each tree or vine, or apply a line of baits just ahead of the advancing army of grasshoppers, placing a

tablespoonful of the mash every 6 or 8 feet, and following up with another line behind the first.

Bran and Paris green, on the authority of Prof. J. B. Smith, thoroughly mixed and sprinkled dry on cabbage heads proved a most successful remedy for cabbage worms, the latter preferring the poisoned bran to the cabbage, to their prompt undoing. The same dry mixture has been successfully employed against cutworms and is recommended by Smith for the army worm, running it in rows 10 feet apart across the infested field.

For sow bugs, or pill bugs, which frequently are injurious pests to tender flowering plants and vegetables grown under frames or in glass houses, poisoned slices of potato have proven the most effectual remedy. The freshly sliced potato may be poisoned by dipping in a strong arsenical solution, or by dusting thickly with a dry arsenical, and distributed over the beds. Pansy beds have been notably protected in this way, and a Michigan vegetable grower reports that in two nights he destroyed upward of 24,000 of these bugs by this means in four houses used for lettuce growing.

Another remedy for baiting cutworms and also for wireworms is to distribute poisoned green, succulent vegetation, such as freshly cut clover, in small bunches about in the infested fields. Dip the bait in a very strong arsenical solution, and protect from drying by covering with boards or stones. Renew the bait as often as it becomes dry, or every three to five days. The bran-arsenic bait, as above mentioned, will also answer for cutworms.

TIME TO SPRAY FOR BITING INSECTS.

For the codling moth the apple and pear should receive the first application as soon as the blossoms fall, which is also the time for the second treatment of the scab fungus; the second spraying should be given one week later and before the calyx closes and the fruit turns down on the stem.

The reason for this course arises from the fact that the parent moth comes out in the spring, about the time the blossoms are falling from the apple trees, and glues her eggs on the skin of the young fruit and on the adjacent leaves also. The larvæ, hatching in about a week, crawl about until they find lodgment in the blossom end of the young apples, and before entering the fruit take several meals in the partial concealment formed by the calyx, and doubtless also nibble more or less of the foliage before they reach the apple, if the eggs happen to be deposited on the leaves. During several days, therefore, the little apple worms feed externally, and the object of spraying is to insure their being poisoned by thoroughly coating the leaves, and especially the calyx end of every fruit, with the arsenical mixture. By the time the calyx closes most of the larvæ will have entered it and will be so

protected by the folding in of the leaves of the calyx that they will be beyond the reach of any poison later applied. In the northern portion of the United States, where the codling moth is single-brooded, this early treatment is all that is necessary. With the exception, however, of rather limited districts, as, for example, northern New York and New England, the codling moth is double, or more numerously, brooded, and spraying must be kept up until late in the season or until the fruit is half or two-thirds grown, and in such regions also the arsenical poisoning must be supplemented with the old banding system. A great many of the common leaf-feeding enemies of apple trees are destroyed by the arsenical treatment for the codling moth.

For the curculio of the stone fruits—plum, cherry, peach, etc.—two or three applications should be made; the first as soon as the foliage is well started, the second at the time of the exposure of the young fruit by the falling of the calyx, and perhaps a third a week later, particularly if rains have intervened after the last treatment. The poison here acts to destroy the parent curculio instead of the young larvæ, which, hatching from eggs placed beneath the skin of the fruit, are not affected by the poison on the outside. The adult curculio, however, as soon as it comes from its hibernation, feeds on the bloom and foliage, and later on the young fruit also, and is destroyed by the arsenical before its eggs are deposited.

For leaf-feeding insects in general, such as the Colorado potato beetle, blister beetles, elm leaf-beetle, maple worm, etc., the application should be made at the earliest indication of injury and repeated as often as necessary.

Fruit trees should never be sprayed when in bloom, on account of the liability of poisoning honeybees or other insects useful as cross fertilizers.

CARE IN USE OF ARSENICALS.

It must be remembered that these arsenicals are very poisonous and should be so labeled. If ordinary precautions are taken, there is no danger to man or team attending their application. The wetting of any, which can not always be avoided, is not at all dangerous, on account of the great dilution of the mixture, and no ill effects whatever have resulted from this source. With some individuals the arsenate of lead, when in strong mixture, affects the eyes, but this is unusual and, with a little care in spraying, the mist need not strike the operator at all.

The poison disappears from the plants almost completely within twenty to twenty-five days, and even if the plants were consumed shortly after the application, an impossible quantity would have to be eaten to get a poisonous dose. To illustrate, in the case of the apple, if the entire fruit were eaten, core and all, it would take several barrels at a single sitting to make a poisonous dose (Riley), and with the

cabbage, dusted as recommended above, 28 heads would have to be eaten at one meal to reach this result (Gillette). It is preferable, however, to use other insecticides in the case of vegetables soon to be eaten, and thus avoid all appearance of danger.

INSECTICIDES FOR EXTERNAL SUCKING INSECTS (CONTACT POISONS).

The simple remedies for this class of insects, such as soap, insect powder, sulphur, tobacco decoction, etc., are frequently of value, but need little special explanation. Some brief notes will be given, however, describing the methods of using some of these substances which are easily available and will often be of service, particularly where few plants are to be treated. The standard remedies for this group of insects, viz, crude petroleum, kerosene, and kerosene emulsions, resin washes, lime, sulphur, and salt wash, hydrocyanic-acid gas, and vapor of bisulphide of carbon, will be afterwards treated in the order mentioned.

SOAPS AS INSECTICIDES.

Any good soap is effective in destroying soft-bodied insects, such as plant-lice and young or soft-bodied larvæ. As winter washes in very strong solution, they furnish one of the safest and most effective means against scale insects. The soaps made of fish oil and sold under the name of whale-oil soaps are often especially valuable, but variable in composition and merits. A soap made with caustic potash rather than with caustic soda, as is commonly the case, and not containing more than 30 per cent of water, should be demanded, the potash soap yielding a liquid in dilution more readily sprayed and more effective against insects. The soda soap washes are apt to be gelatinous when cold, and difficult or impossible to spray except when kept at a very high temperature.

For plant-lice and delicate larvæ, such as the pear slug, a strength obtained by dissolving half a pound of soap in a gallon of water is sufficient. Soft soap will answer as well as hard, but at least double quantity should be taken.

As a winter wash for the San Jose and allied scale insects, whale-oil or fish-oil soap is dissolved in water by boiling at the rate of 2 pounds of soap to the gallon of water. If applied hot and on a comparatively warm day in winter, it can be easily put on trees with an ordinary spray pump. On a very cold day, or with a cold solution, the mixture will clog the pump and difficulty will be experienced in getting it on the trees. Trees should be thoroughly coated with this soap wash. Pear and apple trees may be sprayed at any time during the winter. Peach and plum trees are best sprayed in the spring, shortly before the buds swell. If sprayed in midwinter or earlier, the soap solution

seems to prevent the development of the fruit buds, and a loss of fruit for one year is apt to be experienced, the trees leafing out and growing, however, perhaps more vigorously on this account. The soap treatment is perfectly safe for all kinds of trees, and is very effective against the scale. With large trees, or badly infested trees, preliminary to treatment it is desirable with this as well as other applications to prune them back very rigorously. This results in an economy of spray and makes much more thorough and effective work possible. The soap can be secured in large quantities at from 3½ cents to 4 cents a pound, making the mixture cost, as applied to the trees, from 7 cents to 8 cents a gallon.

PYRETHRUM, OR INSECT POWDER.

This insecticide is sold under the names of Buhach and Persian insect powder, or simply insect powder, and is the ground-up flowers of the Pyrethrum plant. It acts on insects externally through their breathing pores, and is fatal to many forms both of biting and sucking insects. It is not poisonous to man or the higher animals, and hence may be used where poisons would be objectionable. Its chief value is against household pests, such as roaches, flies, and ants, and in greenhouses, conservatories, and small gardens, where the use of arsenical poisons would be inadvisable.

It is used as a dry powder, pure or diluted with flour, in which form it may be puffed about rooms or over plants. On the latter it is preferably applied in the evening, so as to be retained by the dew. To keep out mosquitoes, and also to kill them, burning the powder in a tent or room will give satisfactory results.

It may also be used as a spray at the rate of 1 ounce to 2 gallons of water, but in this case should be mixed some twenty-four hours before being applied. For immediate use, a decoction may be prepared by boiling in water from five to ten minutes.

SULPHUR.

Flowers of sulphur is one of the best remedies for plant mites, such as the red spider, the six-spotted orange mite, and the rust mite of citrus fruits. It may be applied in several forms, the simplest of which is its use as a dry powder dusted over the trees with powder bellows or any broad-casting device, preferably in the early morning when the foliage is damp with dew or immediately after a rain. For the rust mite in very moist climates, such as that of Florida, to keep the fruit bright it is sufficient to merely sprinkle the sulphur about under the trees. The flowers of sulphur may be easily applied also with any other insecticide, such as kerosene emulsion, resin wash, or a soap wash, mixing it up first into a paste and then adding it to the spray tank at a rate of from a pound to two pounds to 50 gallons.

Somewhat more uniform results can be obtained perhaps by getting the sulphur into solution, either dissolving it with lye or by boiling it with lime.

In making the lye-sulphur wash, first mix 20 pounds of flowers of sulphur into a paste with cold water, then add 10 pounds of pulverized caustic soda (98 per cent). The dissolving lye will boil and liquefy the sulphur. Water must be added from time to time to prevent burning, until a concentrated solution of 20 gallons is obtained. Two gallons of this is sufficient for 50 gallons of spray, giving a strength of 2 pounds of sulphur and 1 of lye to 50 gallons of water. An even stronger application can be made without danger to the foliage. This mixture can also be used in combination with other insecticides.

The chemical combination of sulphur and lime known as bisulphide of lime is perhaps a better liquid sulphur solution than the last as a remedy for mites. It may be very cheaply prepared by boiling together for an hour or more, in a small quantity of water, equal parts of flowers of sulphur and stone lime. A convenient quantity is prepared by taking 5 pounds of sulphur and 5 of lime and boiling in 3 or 4 gallons of water until the ingredients combine, forming a brownish liquid. This may be diluted to make 100 gallons of spray.

Almost any of the insecticides with which the sulphur application may be made will kill the leaf or rust mites, but the advantage of the sulphur arises from the fact that it forms an adhering coating on the leaves, which kills the young mites coming from the eggs, which are very resistant to the action of insecticides and result in the plants being reinfested unless protected by the sulphur deposit.

A popular fallacy.—A strongly intrenched popular fallacy, often exposed but constantly being revived, is that sulphur is a valuable remedy against insects when put into holes bored into the trunks of trees, the idea being that the sulphur, when plugged in, is carried up by the movement of the sap into the branches and distributed in the foliage, rendering the latter distasteful to insects. In point of fact the sulphur remains exactly where it is placed, and is of no possible advantage from an insecticide standpoint or any other, and furthermore the treatment is mischievous in that it injures to that extent the soundness of the trunk.

PETROLEUM OILS.

The emulsions of kerosene, or coal oil, with soap or milk have long been the standard insecticides for this class of insects, and especially the plant-lice and scale insects, and these emulsions still are the safest and most reliable means of getting these oils upon plants. The use of kerosene in the pure state as an insecticide was early experimented with by Comstock and Hubbard, and the feasibility of such applications was demonstrated, but the greater safety in the use of the emulsions resulted in a discontinuance of the use of the pure oils. Especially

in the last two or three years, however, the use of these oils in the pure state has come into very general vogue, more particularly as winter washes for the San Jose scale and allied scale insects, the value of the crude oil being especially demonstrated by Prof. J. B. Smith. The petroleum oils may also be used mechanically combined with water by means of especially adapted spray pumps.

In addition to its use as a direct application to plants, kerosene is often used as a means of destroying insects by jarring the latter from plants into pans of water on which a little of the oil is floating, or by jarring them upon cloths or screens saturated with kerosene, preferably the crude oil. The same principle is illustrated in some of the hopper-dozers, or machines for collecting locusts and grass-leaf hoppers.

As a remedy for mosquitoes, kerosene has proved very effective. It is employed to destroy the larvæ of the mosquitoes in their favorite breeding places in small pools, still ponds, or stagnant water; and where such bodies of water are not sources of drinking supply or of value for their fish, especially in the case of temporary pools from rains, which frequently breed very disagreeable local swarms, the use of oil is strongly recommended. The kerosene is applied at the rate of 1 ounce to 15 square feet of water surface. It forms a uniform film over the surface and destroys all forms of aquatic insect life, including the larvæ of the mosquito, and also the adult females coming to the water to deposit their eggs. The application retains its efficiency for several weeks, even with the occurrence of heavy rains. A light grade of fuel oil is preferred for this purpose.

The methods of using kerosene in the pure state and as emulsions with soap and milk follow.

Pure kerosene treatment.—This consists in spraying the trees with ordinary illuminating oil (coal oil or kerosene). The application is made at any time during the winter, preferably in the latter part, and by means of a spray pump making a fine mist spray. The application should be attended with the greatest care, merely enough spray being put on the plant to moisten the trunk and branches without causing the oil to flow down the trunk and collect about the base. With the use of this substance it must be constantly borne in mind that careless or excessive application of the oil will be very apt to kill the treated plant. The application should be made on a bright, dry day, so that the oil will evaporate as quickly as possible. On a moist, cloudy day the evaporation is slow, and injury to the plant is more apt to result. If the kerosene treatment be adopted, therefore, it must be with a full appreciation of the fact that the death of the tree may follow. This oil has been used, however, a great many times and very extensively without any consequent injury of any kind. On the other hand, its careless use has frequently killed many valuable trees. Its advantages

are its availability and its cheapness, kerosene spreading very rapidly and much less of it being required to wet the tree than of a soap and water spray. Pure kerosene is more apt to be injurious to peach and plum than to pear and apple trees, and the treatment of the former as with the soap wash should be deferred until spring, just before the buds swell. With young trees especially, it is well to mound up about the trunk a few inches of earth to catch the downflow of oil, removing the oil-soaked earth immediately after treatment.

The crude-petroleum treatment.—Crude petroleum is used in exactly the same way as is the common illuminating oil referred to above. Its advantage over kerosene is that, as it contains a very large percentage of the heavy oils and paraffin, it does not penetrate the bark so readily, and, on the other hand, only the light oils evaporate, leaving a coating of the heavy oils on the bark, which remains in evidence for months and prevents any young scale which may have escaped from the individuals that were not reached by the spray from getting a foothold. Crude petroleum comes in a great many different forms, depending upon the locality, the grade successfully experimented with in the work of this Division showing 43° Baumé. The experience of Prof. J. B. Smith indicates that crude oil showing a lower Baumé than 43° is unsafe and more than 45° is unnecessarily high. The lower specific gravity indicated (43°) is substantially that of the refined product, the removal of the lighter oils in refining practically offsetting the removal of the paraffin. The same cautions and warnings apply to the crude as to the refined oil.

The oil-water treatment.—Various pump manufacturers have now placed on the market spraying machines which mechanically mix kerosene or crude petroleum with water in the act of spraying. The proportion of kerosene can be regulated so that any desirable percentage of oil can be thrown out with the water. A 10-per-cent-strength kerosene can be used for a summer spray on trees where the San Jose scale is multiplying rapidly and it is not desirable to let it go unchecked until the time for the winter treatment. The winter treatment with the water-kerosene sprays may be made at a strength of 20 per cent of the oil. Applications of the oil-water spray should be attended with the same precautions as with the pure oil, and there is even somewhat greater risk, owing to the natural tendency one has to apply the dilute mixture much more freely than the pure oil. The application should be merely enough to wet the bark and should not, to any extent, at least, run down the trunk. The collection of water and oil about the trunk is just as dangerous to the tree as the pure oil.

In the use of the oil sprays noted above, one who has not had experience with them is advised to make some careful preliminary tests to fully master the process. It is well also, with the oil-water mixtures, to test the pump from time to time, spraying into a glass jar or bottle

to determine by actual measurement whether the percentage of oil and water is being properly maintained.

Kerosene emulsion—Soap formula—

Kerosene	gallons	2
Whale-oil soap (or 1 quart soft soap)	pound	½
Water	gallon	1

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

For the treatment of large orchards or in municipal work requiring large quantities of the emulsion, it will be advisable to manufacture it with the aid of a steam or gasoline engine, as has been very successfully and economically done in several instances, all the work of heating, churning, etc., being accomplished by this means.

The use of whale-oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, and does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and 1 quart of it may be taken in lieu of the hard soaps.

In limestone regions, or where the water is very hard, some of the soap will combine with the lime or magnesia in the water and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water employed; but better than either, follow the milk emulsion formula, with which the character of the water, whether hard or soft, does not affect the result.

The distillate emulsion.—This wash was originated by Mr. F. Kahles, of Santa Barbara, Cal. It has been recommended by the California State Board of Horticulture and has found very general use in the citrus sections of the State. It is substantially an emulsion of crude petroleum made in the same way as the kerosene emulsion described above, except that a greater amount of soap and only half as much oil proportionately is used. The lessened quantity of oil enables it to be made comparatively cheaply, and in spite of this reduction in the oil, the wash is, if anything, stronger than kerosene emulsion, judging from the experience of the writer with both these washes in southern California.

It is termed distillate spray, because the oil used is a crude distillate of the heavy California petroleum. The product used for preparing the emulsion should have a gravity of about 28° Baumé, and is the crude oil minus the lighter oil, or what distills over at a temperature between 250° and 350° C. In general characteristics it is very similar to lubricating oil. The emulsion, or, as it is genereally known, "cream," is prepared as follows: Five gallons of 28° gravity distillate; 5 gallons of water, boiling; 1 to 1½ pounds of whale-oil soap. The soap is dissolved in hot water, the distillate added, and the whole thoroughly emulsified by means of a power pump until a rather heavy, yellowish, creamy emulsion is produced. The product is very similar to, but rather darker in color than the ordinary kerosene emulsion. For use on citrus trees it is diluted with from twelve to fifteen parts of water, the stronger wash for the lemon and the weaker for the orange. The "distillate cream" is commonly prepared and sold by oil companies or individuals at from 10 to 12 cents a gallon, making the diluted mixture cost in the neighborhood of a cent a gallon.

In using both of the above emulsions, it is advisable to first break the water by the addition of a little lye, a fourth-pound of lye being ample for 50 gallons of water.

Kerosene emulsion (milk formula)—

Kerosene	gallons	2
Milk (sour)	gallon	1

Heating is unnecessary in making the milk emulsion, which otherwise is churned as in the former case. The change from a watery liquid to a thick buttery consistency, much thicker than with the soap, takes place very suddenly after three to five minutes' agitation. With sweet milk difficulty will frequently be experienced, and if the emulsion does not result in five minutes, the addition of a little vinegar will induce prompt action. It is better to prepare the milk emulsion from time to time for immediate use, unless it can be stored in quantity in air-tight jars, otherwise it will ferment and spoil after a week or two.

How to use the emulsions.—During the growing period of summer, for most plant-lice and other soft-bodied insects, dilute the emulsion with from 15 to 20 parts of water; for the red spider and other plant mites the same, with the addition of 1 ounce of flowers of sulphur to the gallon; for scale insects, the larger plant-bugs, larvæ, and beetles, dilute with from 7 to 9 parts of water; apply with spray pump.

For winter applications to the trunks and larger limbs of trees in the dormant and leafless condition, to destroy scale insects stronger mixtures may be used, even to the pure emulsion, which latter can not be sprayed successfully, but may be applied with brush or sponge. Diluted with one or more parts of water it may be applied in spray without difficulty. The use of the pure emulsion is heroic treatment and only advisable in cases of excessive infestation, and in general it is much better and safer to defer the treatment until the young scales

hatch in the spring, when the nine-times diluted wash may be used with more certain results and without danger to plants. The winter treatment should be followed by a use of the spring wash to destroy any young which may come from female scales escaping the stronger mixture.

Cautions in use of oil washes.—In the use of kerosene washes, and, in fact, of all oily washes on plants, the application should be just sufficient to wet the plant, without allowing the liquid to run down the trunk and collect about the crown. Usually around the crown, in the case of young trees at least, there is a cavity formed by the swaying of the plants in the wind, and accumulation of the insecticide at this point, unless precautions be taken, may result in the death or injury of the plant. Under these conditions it may be advisable to mound up the trees before spraying and firmly pack the earth about the bases. Care should be taken in refilling the tank that no free oil is allowed to accumulate gradually in the residue left at the bottom, when spraying with emulsions or oil-water mixtures.

THE RESIN WASH.

This wash has proved of greatest value in California, particularly against the red scale (*Aspidiotus aurantii*) and the black scale (*Lecanium oleæ*) on citrus plants, and the last named and the San Jose scale (*Aspidiotus perniciosus*) on deciduous plants, and will be of use in all similar climates where the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and where, owing to the warmth, the multiplication of the scale insects continues almost without interruption throughout the year. Where rains are liable to occur at short intervals, and in the Northern States, the quicker-acting and stronger kerosene washes and heavy soap applications are preferable. The resin wash acts by contact, having a certain caustic effect, but principally by forming an impervious, smothering coating over the scale insects. The application may be more liberal than with the kerosene washes, the object being to wet the bark thoroughly.

The wash may be made as follows:

Resin	pounds	20
Crude caustic soda (78 per cent)	do	5
Fish oil	pints	2½
Water to make	gallons	100

Ordinary commercial resin is used, and the caustic soda is that put up for soap establishments, in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (98 per cent) used—3½ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances, with the oil, in a kettle with water to cover them to a depth of 3 or 4 inches. Boil about two hours, making occasional additions of water, or until the compound

resembles very strong, black coffee. Dilute to one-third the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed the mixture should be perfectly fluid, without sediment, and should any appear in the stock mixture reheating should be resorted to, and in fact the wash is preferably applied hot.

As a winter wash for scale insects, and particularly for the more resistant San Jose scale (*Aspidiotus perniciosus*), stronger washes are necessary. In southern California, for this latter insect, the equivalent of a dilution one-third less, or 66⅔ gallons instead of 100, has given very good satisfaction. In Maryland, with this insect, it has proved necessary to use the wash at six times the summer strength to destroy all of the well-protected hibernating scales; and with other scale insects much stronger mixtures than those used in California have proved ineffectual in the East. For regions, therefore, with moderately severe winters the use of the resin wash to destroy hibernating scale insects seems inadvisable.

THE LIME, SULPHUR, AND SALT WASH.

This is the invariable remedy for the San Jose scale in California and much of the Pacific coast, and it is, under the conditions of climate obtaining in that region, undoubtedly very effective. Early experience with this wash in the East threw doubt on its efficiency as an insecticide under the climatic conditions prevailing throughout the eastern half of the United States. Some later experiments, however, have shown that wherever the weather conditions happen to be very favorable, duplicating, in a measure, the conditions on the Pacific coast, this wash is effective in the East also. Unfortunately, the weather conditions can not be relied on, and therefore its use in the East is not recommended. But if a considerable period (ten days or two weeks, at least) of dry weather could be assured after the treatment, it would probably give very satisfactory results when properly made and applied. It is a winter application and is applied in January or February, or at any time prior to spring growth. It may be prepared after the following formula: Unslaked lime, 30 pounds; sulphur, 20 pounds; salt, 15 pounds. Place all together in a barrel with 30 or 40 gallons of water and boil with steam for three or four hours. For use, the mixture should be diluted to make 60 gallons of wash, and may be preferably applied at a high temperature. It may be made in smaller quantities by boiling over a fire, using the same proportion of ingredients. This wash is applied nearly every year, or as often as the San Jose scale develops in any considerable numbers. It has the advantage of leaving a limy coating on the trees, which acts as a deterrent to the young scale lice, and where it is not washed by rains retains its value as an insecticide coating for some time, remaining in evidence on the trees for several months.

This wash is of value also as a fungicide, protecting stone fruits from leaf fungi, and is also a protection against birds, the common California linnet doing great damage to buds in January and February. The wash is almost invariably made and applied by contractors, and costs about 5 cents per gallon applied to the trees.

TIME TO SPRAY FOR SUCKING INSECTS.

For the larger plant-bugs and the aphides, or active plant-lice, and all other sucking insects which are present on the plants injuriously for comparatively brief periods, or at most during summer only, the treatment should be immediate, and if in the form of spray on the plants, at a strength which will not injure growing vegetation.

For scale insects and some others, as the pear Psylla, which hibernate on the plants, two or more strengths are advised with most of the liquid insecticides recommended, the weaker for summer applications and the more concentrated as winter washes. The summer washes for scale insects are most effective against the young, and treatment should begin with the first appearance of the larvæ of the spring or any of the later broods, and should be followed at intervals of seven days with two or three additional applications. The first brood, for the majority of species in temperate regions, will appear during the first three weeks in May. Examination from time to time with a hand lens will enable one to determine when the young of any brood appear.

The winter washes may be used whenever summer treatment can not be successfully carried out, and are particularly advantageous in the case of deciduous plants with dense foliage which renders a thorough wetting difficult in summer, or with scale insects which are so irregular in the time of disclosing their young that many summer treatments would be necessary to secure anywhere near complete extermination. In the winter also, with deciduous trees, very much less liquid is required, and the spraying may be much more expeditiously and thoroughly done. In the case of badly infested trees, a vigorous pruning is advisable as a preliminary to treatment.

As winter washes for temperate regions the kerosene washes and whale-oil soap solutions have so far given the best results. In the growing season any of these stronger washes would cause the loss of foliage and fruit, and the more concentrated probably the death of the plant.

THE GAS TREATMENT.

The use of hydrocyanic-acid gas originated in southern California in work against citrus scale insects, and was perfected by a long period of experimentation by an agent of this division, Mr. D. W. Coquillett. It is undoubtedly the most thorough method known of destroying scale insects and especially is it the best treatment for citrus trees, the abundance of foliage and nature of growth of which renders thorough spray-

ing difficult, but, on the other hand, enables the comparatively heavy tents employed in fumigation to be thrown or drawn over the trees rapidly without danger of breaking the limbs. One good gassing is usually the equivalent of two or three sprayings, the gas penetrating to every particle of the surface of the tree and often effecting an almost complete extermination, rendering another treatment unnecessary for two years or more.

The gas treatment is just as effective also against scale insects on deciduous orchard fruit trees, as has been demonstrated by a good deal of work recently done in the East, notably in Maryland by Professor Johnson; but the difficulty and expense of the treatment as measured by the value of the crop protected makes it as a rule prohibitive in the case of deciduous fruits. This does not apply, however, to nursery stock, which may be brought together compactly and treated in mass

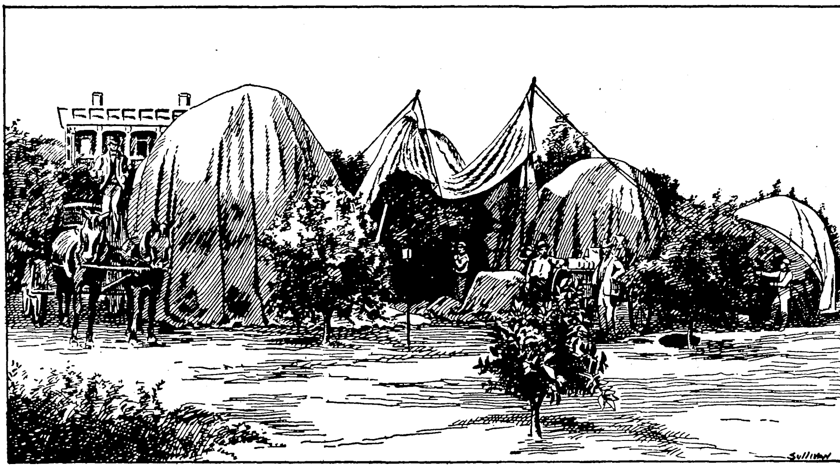

FIG. 3.—Tenting trees for gas treatment, San Diego, Cal. (author's illustration).

in fumigating rooms or houses. The general spread of the San Jose scale in the East has made such fumigation of nursery stock, even when infestation is not shown or suspected, a necessary procedure before shipment or sale, to give the utmost assurance of safety to the purchaser. Similarly this gas is the principal agency employed in disinfecting-plant material coming to California from abroad, and will be the chief agency for such work wherever quarantine regulations prevail. (See fig. 3.)

Another very important use for hydrocyanic-acid gas, recently demonstrated, is as a means of controlling insect pests in greenhouses and cold frames. The process is a special one, however, and entails considerable of variation, owing to the wide range of plants to be considered. The details of the process are given in a special publication of this Division (circular No. 37, second series), which will be supplied to anyone interested.

The employment of this gas for disinfecting houses of insect pests and vermin has also suggested itself and has been a matter of some experimentation, and the feasibility of using the gas for such purposes is not to be questioned. Nevertheless, this gas is so extremely poisonous and deadly that its employment in dwelling-houses can under no circumstances be recommended to anyone who has not had previous experience with it, as the least carelessness would probably mean the loss of human life. For house disinfection the use of the gas is substantially as in fumigation of nursery stock.

In all work with hydrocyanic-acid gas, its extremely poisonous nature must be constantly kept in mind and the greatest precautions taken to avoid inhaling it.

Fumigation of nursery stock.—For the fumigation of nursery stock or imported plant material in a dormant or semi-dormant condition, a building or room should be provided, made so that it can be closed practically air-tight and fitted with means of ventilation above and at the side, operated from without, so that the poisonous gas can be allowed to escape without the necessity of anyone entering the chamber. The gas is generated by combining potassium cyanide, sulphuric acid, and water. The proportions of the chemicals are as follows: Refined potassium cyanide (98 per cent), 1 ounce; commercial sulphuric acid, 1 ounce; water, 3 fluid ounces to every hundred feet of space in the fumigating room. For comparatively green or tender material the same amounts may be used to 150 cubic feet of space.

The generator of the gas may be any glazed earthenware vessel of 1 or 2 gallons capacity and should be placed on the floor of the fumigating room, and the water and acid necessary to generate the gas added to it in the order named. The cyanide should be added last, preferably in lumps the size of a walnut, and the premises promptly vacated and the door made fast. Treatment should continue forty minutes.

Orchard fumigation.—In the fumigation of growing stock, citrus or other, the treatment consists in inclosing the tree with a tent and filling the latter with poisonous fumes generated in the same way as described for nursery stock except that less of the chemicals is used. The treatment is made at night for trees in foliage, which includes all work in citrus orchards, to avoid the much greater likelihood of injury to tender foliage in the sunlight.

The proportions of the chemicals vary with the size of the tree and, as now employed in California, are considerably in excess of the amounts recommended a few years ago, or as recently as 1898. The gas treatment was first chiefly used against the black scale and at a season of the year when these scales were all in a young stage and easily killed. The effort is now made not only to kill the black scale, but also the red scale, and to do more effective work even than formerly with both of these scale insects. The proportion of chemicals ordi-

narily advised and commonly employed in Los Angeles, Orange, and some other counties in southern California are indicated in the subjoined table, published by the horticultural commissioners of Riverside County, Cal.

TABLE 1.—*Proportion of chemicals for ordinary use.*

Height of tree.	Diameter of tree.	Water.	Cyanide, C. P., 98 per cent.	Sulphuric acid, 66 per cent.
Feet.	*Feet.*	*Ounces.*	*Ounces.*	*Ounces.*
6	4	2	1	1
8	6	3	1½	1½
10	8	5	2½	2½
12	14	11	5	5½
16	16	17	8	9
20	16–20	22	10	12
20–24	18–22	30	14	16
24–30	20–28	34	16	18
30–36	25–30	52	24	28

The amounts here recommended are thoroughly effective for the black scale at the proper season, and generally effective also for the California red scale and other armored scales. Where the treatment is designed to be absolutely one of extermination and the expense is not considered, from one-third to one-half more of cyanide and acid is employed, as indicated by the subjoined table, furnished by Mr. G. Havens, of Riverside. The amounts here recommended may be employed also for compact trees with dense foliage or in moist coast regions where stronger doses are needed.

TABLE 2.—*Excessive amounts employed for absolute extermination.*[1]

Height of tree.	Diameter through foliage.	Water.	Sulphuric acid.	Cyanide.	Time to leave tent on tree.
Feet.	*Feet.*	*Fluid ozs.*	*Fluid ozs.*	*Ounces.*	*Minutes.*
6	3–4	3	1½	¾–1	20
8	5–6	6	2½	2	30
10	7–10	15	5–6	4–5	35–40
12	9–12	20–30	7–9	5½–7½	40
14	12–14	30–35	9–12	8–10	40
16	12–15	35–40	12–14	10–12	40
18	14–16	45–55	15–18	12–15	40–50
20	16–18	60–70	20–22	16–20	45–50
22	16–18	70–75	22–25	20	50
24	18–20	75–80	25–30	22–26	50
27	20–24	85–100	30–36	28–32	60
30	20–28	100–110	36–44	32–38	60

[1] A fumigation of the orangery of the Department December 3,1900, demonstrated that 0.15 of a gram of cyanide to the cubic foot, or a little more than half an ounce to the hundred cubic feet, is completely exterminative of scale insects, effectually killing the eggs, even of the black, purple, and other scales. The strength mentioned is that ordinarily recommended for violet houses, and the results are scarcely comparable to the proportions recommended in Tables 1 and 2, for the reason that in these tables the amount of cyanide is greatly lessened with larger trees, and, furthermore, that the orangery probably retained the gas more effectually than would be the case with cloth tents. Nevertheless, it is interesting to know that a comparatively inconsiderable strength of cyanide, when applied under the best conditions, will prove thoroughly effective against the eggs as well as the insects in all stages.

The duration of the treatment indicated in the second table varies with the size of the tree, but in general at least forty minutes should be allowed.

General directions for orchard fumigation.—The first table indicates for the smaller trees twice as much cyanide and acid as was formerly advised, and for the larger trees three times the former amounts. The second table indicates a considerable increase over the first, and three or four times as much of the chemicals as was generally recommended as late as 1898. The greater expense entailed by this larger quantity of chemicals is offset by the more effective results and the consequently longer intervals between treatments. Mr. Havens suggests that for small trees ordinary earthenware vessels may be used to generate the gas. For large trees requiring heavy doses, tall wooden pails have proven more practicable, using two generators for the very largest trees. It is important that the water be put in the vessel first, and then the acid, and lastly the cyanide. If the water and cyanide are put in the vessel first and the acid poured in afterwards there is danger of an explosion which will scatter the acid and burn the tents and the operator. In the spring, when the trees are tender with new growth, and in early fall when the oranges are nearly grown and the skins are liable to be easily marred, and also with young trees, it is advisable to add one-third more water than ordinarily used, or the cyanide in larger lumps. This causes the gas to generate more slowly and with less heat, and if the tents are left over the trees a third longer the effectiveness of the treatment will not be lessened.

The treatment is made at night, and the person handling the chemicals should always have an attendant with a lantern, to hold up the tent and enable the cyanide to be quickly dropped into the generator, and to facilitate the prompt exit of the operator.

Trees are fumigated for the black scale in southern California in October, or preferably in November. The red and other scales may be treated with gas at any time, but preferably at the season already alluded to. In California most of the work is done by contract, or under the direct supervision of the county horticultural commissioners, in some cases the tents and material being furnished at a mere nominal charge, together with one experienced man to superintend the work, while a crew of four men operate the tents, the wages of the director and men being paid by the owner of the trees.

Construction and handling of tents.—The tents now employed are of two kinds, the "sheet" tent of octagonal shape for large trees, and the "ring" tent for trees under 12 feet in height. The ring tents, or, as they are also called, the bell tents, are bell-shaped and have a hoop of half-inch gas pipe fastened within a foot or so of the opening. Two men can easily throw one of these tents over a small tree. An equipment of 36 or 40 ring tents can be handled by four men. They are rapidly thrown over the trees by the crew, and the director follows

closely and introduces the chemicals. By the time the last tent has been adjusted the first one can be removed and taken across to the adjoining row. An experienced crew, with one director, can treat 350 to 400 five-year-old trees, averaging in height 10 feet, in a single night of eleven or twelve hours. The cost under such conditions averages about 8 cents a tree.

With large trees the large sheet tents are drawn over them by means of uprights and pulley blocks. Two of these sheets are necessary for very large trees, the first being drawn halfway over and the second drawn up and made to overlap the first. In the case of trees from 24 to 30 years old and averaging 30 feet in height, about 50 can be treated in a night of ten or twelve hours with an equipment of 12 or 15 tents, the cost being about 75 cents per tree. It is not practicable to treat trees above 30 feet in height.

FIG. 4.—Method of hoisting sheet tent (after Craw).

The handling of the bell tents is simple and needs no further description, but the large tents are not so easily operated, and the method of adjusting the great flat octagonal sheets over the trees, while simple enough when once understood, warrants a description. The machinery employed consists of two simple uprights, with attached blocks and tackle (fig. 4). The uprights are about 25 feet high, of strong Oregon pine, 2 by 4 inches, and are provided at the bottom with a braced crossbar to give them strength and to prevent their falling to either side while the tent is being raised. A guy rope is attached to the top of each pole and held to steady it by two of the crew stationed at the rear of the tree. The tent is hoisted by means of two ropes 70 feet long, which pass through blocks, one fixed at the top of the pole and the other free. The tent is caught near the edge by taking a hitch

around some solid object, such as a green orange, about which the cloth is gathered. By this means the tent may be caught anywhere without the trouble of reversing and turning the heavy canvas to get at rings or other fastenings attached at particular points. The two remaining members of the operating crew draw the tent up against and over one side of the tree by means of the pulley ropes sufficiently to cover the other side of the tree when the tent falls. The poles and tent together are then allowed to fall forward, leaving the tent in position. Sufficient skill is soon acquired to carry out rapidly the details of this operation, so that little time is lost in transferring the tents from tree to tree, even when the trees approximate the limit in height. A single pair of hoisting poles answers for all the tents used.

Some of the tents employed are of great size, one described by Mr. Havens having a diameter of 76 feet. It is constructed of a central piece 50 feet square, of 10-ounce army duck. Four triangular side pieces or flaps of 8-ounce duck, 10 feet wide in the middle, are strongly sewed to each side of the central sheet, forming an octagonal sheet 70 feet in diameter. About the whole sheet is then sewed a strip of 6-ounce duck, 1 yard wide. The tent is handled by means of ropes and pulleys. A 1½-inch manila rope is sewed about the border of the central piece in an octagonal pattern. Rings are attached to this rope at each of the eight corners thus formed, and also on either side of the tent. To these rings the pulley ropes are fastened, and the tent is elevated over the trees and handled very much as indicated in fig. 4.

The canvas for the tents, blue or brown drilling or 8-ounce duck, may be rendered comparatively impervious to the gas by painting lightly with boiled linseed oil. This has the objection, however, of stiffening the fabric and adding considerably to its weight; it also frequently leads to its burning by spontaneous combustion unless carefully watched until the oil is dry. A much better material than oil is found in a product obtained from the leaves of the common prickly pear cactus (*Opuntia engelmanni*), which grows in abundance in the Southwest. The liquor is obtained by soaking chopped-up leaves in water for twenty-four hours. It is given body and color by the addition of glue and yellow ocher or venetian red, and is applied to both sides of the canvas and rubbed well into the fiber of the cloth with a brush.

Some practical experience is necessary to fumigate successfully, and it will therefore rarely be wise for anyone to undertake it on a large scale without having made preliminary experiments.

BISULPHIDE OF CARBON VAPOR.

In line with the use of hydrocyanic-acid gas is the employment of the vapor of bisulphide of carbon to destroy insects on low-growing plants, such as the lice on melon and squash vines. The treatment, as

successfully practiced by Professors Garman and Smith, consists in covering the young vines with small tight boxes 12 to 18 inches in diameter, of either wood or paper, and introducing under each box a saucer containing one or two teaspoonfuls (1 or 2 drams) of the very volatile liquid, bisulphide of carbon. The vines of older plants may be wrapped about the hill and gathered in under larger boxes or tubs, and a greater, but proportional, amount of bisulphide used. The covering should be left over the plants for three-quarters of an hour to an hour, and with 50 to 100 boxes a field may be treated with comparative rapidity.

DUSTING AND SPRAYING APPARATUS.

For the application of powders the dusting bags already described are very satisfactory, or for garden work some of the small powder bellows and blowers are excellent. The best of these cost about $2 each and are on the market in many styles.

FIG. 5.—Different methods of treating plants for insects (author's illustration).

Better apparatus is required for the wet applications where successful results require the breaking up of the liquid into a fine mist-like spray. The essential features of such an apparatus are a force pump, several yards of one-half-inch cloth-reenforced hose with bamboo hoisting rod, and a spray tip. The size of the apparatus will depend on the amount of vegetation to be treated. For limited garden work and for the treatment of low plants the knapsack pumps or the small bucket force pumps are suitable, the former costing about $14 and the latter from $6 to $9.

Ready-fitted pumps, knapsack, and others, for the application of insecticides, are now made by all the leading pump manufacturers of this country, and also large reservoirs with pump attached for extended orchard operations, the price of the latter ranging from $25 to $75.

The cost of a spraying outfit for orchard work may be greatly reduced by combining a suitable pump and fixtures with a home-constructed tank or barrel, to be mounted on a cart or wagon. A spray tank having a capacity of about 150 gallons is a very satisfac-

tory size, and may be conveniently made 4 feet long by 2½ wide by 2 deep, inside measurements. It should be carefully constructed, so as to be water-tight, and should be strengthened by four iron bolts or rods across the ends, one each at the top and bottom. A good double-acting force pump may be obtained from any of the leading pump manufacturers at a cost of from $10 to $20, depending upon whether of iron or brass and the nature of its fittings. For use in very large orchards or in city parks it may be advisable to construct the tank of twice the capacity mentioned, to expedite the spraying and to avoid the more frequent refillings necessary with the smaller tank.

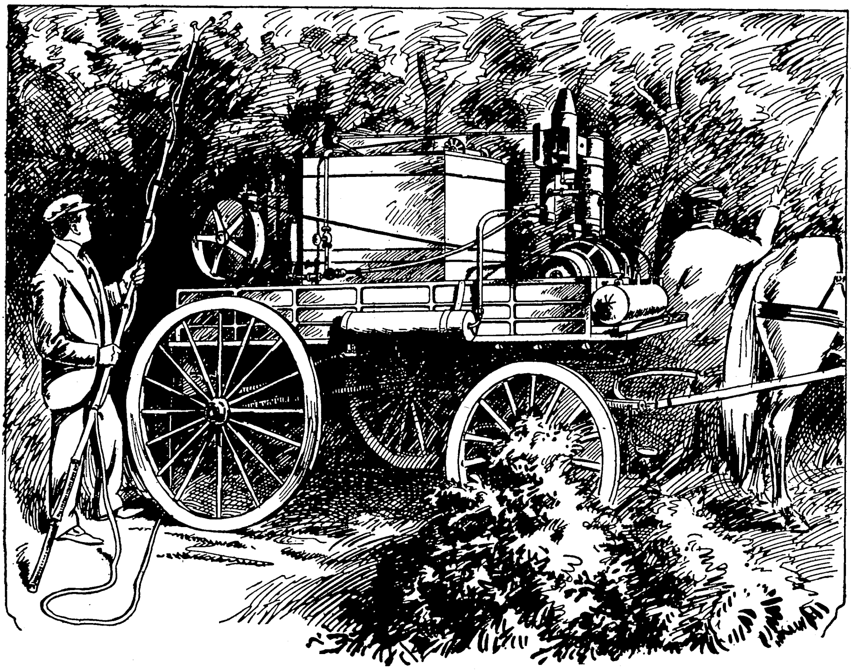

FIG. 6.—Gasoline power spraying outfit of the Division of Entomology, U. S. Department of Agriculture (author's illustration).

For the requirements last mentioned the use of power spraying apparatus of considerable capacity has become somewhat general, particularly in municipal work against shade-tree insects in the East and in spraying the large citrus groves of the Pacific slope. An apparatus of this sort recently built by the Division of Entomology of the Department is illustrated in the accompanying figure (fig. 6). The use of power apparatus for spraying is a special subject, and those interested would do well to consult the article by Dr. L. O. Howard (Yearbook Dept. Agric., 1896, pp. 69–88) giving full descriptive details, with figures, of the important machines now in use.

The more economical spray tips in the amount of liquid required

are the different styles of cyclone nozzles, the best form of which is known to the market generally as the Vermorel nozzle. These are manufactured by the leading spray-pump companies. Other good nozzles are also on the market. The common garden spraying and hose nozzles are much too coarse for satisfactory work, and are wasteful of the liquid.

A prime essential in spraying, especially where the large reservoirs are employed, is to keep the liquid constantly agitated to prevent the settling of the poison to the bottom of the tank. This may be accomplished by constant stirring with a paddle, by shaking, but preferably by throwing a stream of the liquid back into the tank. Many of the larger pumps are now constructed with two discharge orifices with this latter object in view or are provided with special agitators, and the use of such is recommended.

For fruit trees of average size, or, if apple, such as would produce from 10 to 15 bushels of fruit, from 3 to 7 gallons of spray are necessary to wet each tree thoroughly. For smaller trees, such as plum and cherry, 1 gallon to the tree will be sufficient. If an average of 5 gallons to the tree be taken, for an apple orchard of 1,000 trees 5,000 gallons of spray would be required. About 33 pounds of Paris green or London purple would be needed for one spraying if used at the rate of 1 pound to 150 gallons of water, and for the two applications ordinarily recommended 66 pounds. This, for the Paris green, at 20 cents a pound, would amount to $13.20, and the London purple, at 10 cents a pound, to $6.60, or a little over 1 cent a tree for the former and one-half a cent for the latter.

In spraying orchard trees it will be found convenient in going between the rows to spray on each side, half of each tree in the row at a time and finish on the return, rather than attempt to spray all sides of one tree before taking up another.

The object in spraying is to coat every leaf and part of the plant as lightly as compatible with thoroughness, and to avoid waste in doing this a mist spray is essential. The application to any part should stop when water begins to drip from the leaves. A light rain will not remove the poison, but a dashing one will probably necessitate a renewal of the application.

REMEDIES FOR SUBTERRANEAN INSECTS.

Almost entire dependence is placed on the caustic washes, or those that act externally, for insects living beneath the soil on the roots of plants, including both sucking and biting insects, prominent among which are the white grubs, maggots in roots of cabbage, radishes, onions, etc., cutworms, wireworms, apple and peach root-lice, the grape phylloxera, and many others.

The insecticide must be one that will go into solution and be carried

down by water. Of this sort are the kerosene emulsions and resin wash—the former preferable—the potash fertilizers, muriate and kainit, and bisulphide of carbon. The simple remedies are in applications of strong soap or tobacco washes to the soil about the crown; or soot, ashes, or tobacco dust buried about the roots; also similarly employed are lime and gas lime. Submersion, wherever the practice of irrigation or the natural conditions make it feasible, has also proved of the greatest service against the phylloxera.

HOT WATER.

As a means of destroying root-lice, and particularly the woolly louse of the apple, the most generally recommended measure hitherto is the use of hot water, and this, while being both simple and inexpensive, is thoroughly effective, as has been demonstrated by practical experience. Water at nearly the boiling point may be applied about the base of young trees without the slightest danger of injury to the trees, and should be used in sufficient quantity to wet the soil thoroughly to a depth of several inches, as the lice may penetrate nearly a foot below the surface. To facilitate the wetting of the roots and the extermination of the lice, as much of the surface soil as possible should be first removed.

By a hot-water bath slightly infested stock can easily be freed of the aphides at the time of its removal from the nursery rows. The soil should be dislodged and the roots pruned, and in batches of a dozen or so the roots and lower portion of the trunk should be immersed for a few seconds in water kept at a temperature of 130° to 150° F. A strong soap solution similarly heated or a fifteen times diluted kerosene emulsion will give somewhat greater penetration and be more effective, although the water alone at the temperature named should destroy the lice.

Badly infested nursery stock should be destroyed, since it would be worth little even with the aphides removed.

TOBACCO DUST.

Some very successful experiments conducted by Prof. J. M. Stedman demonstrated the very satisfactory protective, as well as remedial, value of finely ground tobacco dust against the woolly aphis. The desirability of excluding the aphis altogether from nursery stock is at once apparent, and this Prof. Stedman shows to be possible by placing tobacco dust freely in the trenches in which the seedlings or grafts are planted and in the orchard excavations for young trees. Nursery stock may be continuously protected by laying each spring a line of the dust in a small furrow on either side of the row and as close as possible to the tree, covering loosely with earth. For large trees, both for protection and the destruction of existing aphides, from 2 to 5

pounds of the dust should be distributed from the crown outward to a distance of 2 feet, first removing the surface soil to a depth of from 4 to 6 inches. The tobacco kills the aphides by leaching through the soil, and acts as a bar for a year or so to reinfestation. The dust is a waste product of tobacco factories, costs about 1 cent per pound, and possesses the additional value of being worth fully its cost as a fertilizer.

KEROSENE EMULSION AND RESIN WASH.

Either the kerosene and soap emulsion or the resin wash, the former diluted 15 times and the latter at the strength of the winter mixture, are used to saturate the soil about the affected plants and either left to be carried down by the action of rains or washed down to greater depths by subsequent waterings.

For the grape phylloxera or the root-louse of the peach or apple, make excavations 2 or 3 feet in diameter and 6 inches deep about the base of the plant and pour in 5 gallons of the wash. If not a rainy season, a few hours later wash down with 5 gallons of water and repeat with a like amount the day following. It is better, however, to make this treatment in the spring, when the more frequent rains will take the place of the waterings.

For root-maggots enough of the wash is put along at the base of the plant to wet the soil to a depth of 1 to 2 inches, preferably followed after an hour with a like amount of water.

For white grubs in strawberry beds or in lawns the surface should be wetted with kerosene emulsion to a depth of 2 or 3 inches, following with copious waterings to be repeated for two or three days. The larvæ go to deeper and deeper levels and eventually die.

POTASH FERTILIZERS.

For white grubs, wireworms, cutworms, corn root-worms, and like insects, on the authority of Prof. J. B. Smith, either kainit or the muriate of potash, the former better, are broadcasted in fertilizing quantities, preferably before or during a rain, so that the material is dissolved and carried into the soil at once. These not only act to destroy the larvæ in the soil, but are deterrents, and truck lands constantly fertilized by these substances are noticeably free from attacks of insects. This, in a measure, results from the increased vigor and greater resistant power of the plant, which of itself more than compensates for the cost of the treatment. The value of these fertilizers against the wireworms is, however, questioned by Prof. J. H. Comstock.

For the root-louse of peach and apple, work the fertilizer into the general surface of the soil about the trees, or put it in a trench about the tree 2 feet distant from the trunk.

For cabbage and onion maggots apply in little trenches along the roots at the rate of 300 to 500 pounds to the acre, and cover with soil.

These fertilizers (and the nitrate of soda is nearly as good) are also destructive to the various insects which enter the soil for hibernation or to undergo transformation.

BISULPHIDE OF CARBON.

This is the great French remedy for the phylloxera, 150,000 acres being now subjected to treatment with it, and applies equally well to all other root-inhabiting lice. The treatment is made at any season except the period of ripening of the fruit and consists in making holes about the vines 1 foot to 16 inches deep and pouring into each about one-half ounce of bisulphide, and closing the hole with the foot. These injections are made about [illegible] feet apart, and not closer to the vines than 1 foot. It is better to make a large number of small doses than a few large ones. Hand injectors and injecting plows are employed in France to put the bisulphide into the soil about the vines, but a short stick or iron bar may be made to take the place of these injectors for limited tracts.

The use of bisulphide of carbon for the woolly aphis is the same as for the grape root-louse. It should be applied in two or three holes about the tree to a depth of 6 to 12 inches and not closer than 1½ feet to the crown. An ounce of the chemical should be introduced into each hole, which should be immediately closed.

For root-maggots a teaspoonful is poured into a hole near the base of the plant, covering as above.

For ant nests an ounce of the substance is poured into each of several holes made in the space occupied by the ants, the openings being then closed; or the action is made more rapid by covering with a wet blanket for ten minutes and then exploding the vapor at the mouth of the holes with a torch, the explosion driving the fumes more thoroughly through the soil.

SUBMERSION.

This very successful means against the phylloxera is now practiced over some 75,000 acres of vineyards in France which were once destroyed by the grape root-louse, and the production and quality of fruit has been fully restored. In this country it will be particularly available in California and in all arid districts where irrigation is practiced; otherwise it will be too expensive to be profitable. The best results are secured in soils in which the water will penetrate rather slowly, or from 6 to 18 inches in twenty-four hours; in loose, sandy soils it is impracticable on account of the great amount of water required. Submersion consists in keeping the soil of the vineyard flooded for from eight to twenty days after the fruit has been gathered and active growth of the vine ceased, or during September or October, but while

the phylloxera is still in active development. Early in September eight to ten days will suffice; in October fifteen to twenty days, and during the winter, as was formerly practiced, forty to sixty days. Supplementing the short fall submergence a liberal July irrigation, amounting to a forty-eight hour flooding, is customary to reach any individuals surviving the fall treatment, and which in midsummer are very susceptible to the action of water.

To facilitate the operation, vineyards are commonly divided by embankments of earth into square or rectangular plots, the former for level and the latter for sloping ground, the retaining walls being protected by coverings of reed grass, etc., during the first year, or until they may be seeded to some forage plant.

This treatment will destroy many other root-attacking insects and those hibernating beneath the soil, and, in fact, is a very ancient practice in certain oriental countries bordering the Black Sea and the Grecian Archipelago.

REMEDIES FOR INSECTS AFFECTING GRAIN AND OTHER STORED PRODUCTS.

GENERAL METHODS OF TREATMENT.

The chief loss in this direction from insects is to grains in farmers' bins, or grain or grain products in stores, mills, and elevators, although in the warmer latitudes much of the injury results from infestation in the field between the ripening of the grain and its storage in bins or granaries. Fortunately, the several important grain insects are amenable to like treatment. Aside from various important preventive considerations, such as, in the South, prompt thrashing of grain after harvesting, the thorough cleansing of bins before refilling, constant sweeping, removal of waste harboring insects from all parts of granaries and mills, and care to prevent the introduction of "weeviled" grain, there are three valuable remedial measures, viz, agitation of the grain, heating, and dosing with bisulphide of carbon.

The value of agitating or handling grain is well known, and whenever, as in elevators, grain can be transferred or poured from one bin into another grain pests are not likely to trouble. The benefit will depend upon the frequency and thoroughness of the agitation, and in France machines for shaking the grain violently have been used with success. Winnowing weeviled grain is also an excellent preliminary treatment.

Raising the temperature of the grain in closed retorts or revolving cylinders to 130° to 150° F. will kill the inclosed insects if continued for from three to five hours, but is apt to injure the germ, and is not advised in case of seed stock. The simplest, cheapest, and most effectual remedy is the use of bisulphide of carbon.

BISULPHIDE OF CARBON.

This is a colorless liquid with very offensive odor, which, however, passes off completely in a short time. It readily volatilizes and the vapor, which is very deadly to insect life, is heavier than air and settles and fills any compartment or bin in the top of which the liquid is placed. It may be distributed in shallow dishes or tins or in saturated waste on the top of grain in bins, and the gas will settle and permeate throughout the mass of the grain. In large bins, to hasten and equalize the operation, it is well to put a quantity of the bisulphide in the center of the grain by thrusting in balls of cotton or waste tied to a stick and saturated with the liquid, or by means of a gas pipe loosely plugged at one end, down which the liquid may be poured and the plug then loosened with a rod. Prof. H. E. Weed reports that in Mississippi the chemical is commonly poured directly onto the grain. In moderately tight bins no further precaution than to close them well need be taken, but in open bins it will be necessary to cover them over with a blanket to prevent the too rapid dissipation of the vapor. The bins or buildings should be kept closed from twenty-four to thirty-six hours, after which a thorough airing should be given them.

Limited quantities at a time may often be advantageously subjected to treatment in small bins before being placed for long storage in large masses, and especially whenever there is danger of introducing infested grain.

The bisulphide is applied at the rate of 1 pound to the ton of grain, or a pound to a cubic space 10 feet on a side.

In the case of mills, elevators, or larger granaries the application may be best made on Saturday night, leaving the building closed over Sunday, with a watchman without to see that no one enters, and to guard against fire. The bisulphide should be first distributed in the lower story, working upward to avoid the settling vapor, using the substance very freely, in waste or dishes, at all points of infestation and over bins throughout the building.

This insecticide may also be used in other stored products, as peas, beans, etc., and very satisfactorily where the infested material can be inclosed in a tight can, chest, or closet for treatment. It may also be employed to renovate and protect wool or similar material stored in bulk.

The bisulphide costs, in 50-pound cans, 10 cents per pound, and in small quantities, of druggists, 25 to 35 cents per pound.

Caution.—The bisulphide may be more freely employed with milling grain than that intended for seeding, since when used excessively it may injure the germ. It must always be remembered that the vapor is highly inflammable and explosive, and that no fire or lighted cigars, etc., should be in the building during its use. If obtained in large quantities it should be kept in tightly closed vessels and away from fire, preferably in a small out-building.

GENERAL CONSIDERATIONS ON THE CONTROL OF INSECTS.

ADVANTAGE OF PROMPT TREATMENT.

The importance of promptness in the treatment of plants attacked by insects can not be too strongly insisted upon. The remedy often becomes useless if long deferred, the injury having already been accomplished or gone beyond repair. If, by careful inspection of plants from time to time, the injury can be detected at the very outset, treatment is comparatively easy and the result much more satisfactory. Preventive work, therefore, should be done as much as possible, rather than waiting for the remedial treatment later; the effort being to forestall any serious injury rather than to patch up damage which neglect has allowed to become considerable.

KILLING INSECTS AS A PROFESSION.

It may often happen that the amount of work in a community is sufficient to induce one or more persons to undertake the treatment of plants at a given charge per tree or per gallon of the insecticide employed. Where this is the case, and the contracting parties are evidently experienced and capable, it is frequently more economical in the end to employ such experienced persons, especially when a guarantee is given, rather than attempt to do the work one's self with the attending difficulty of preparing insecticides and securing apparatus for work on a comparatively small scale. In California this is a common practice, and also in some of our Eastern cities, and has worked excellently.

THE DETERMINATION OF THE RESULT OF TREATMENT.

It is often of importance to know when and how to determine the effect of any treatment applied directly to insects exposed on the surface of plants. In the case of scale insects, especially during the dormant condition in winter, the response to insecticides is very slow and gradual. The scale larvæ, or any young scales during the growing season, are killed in a few minutes, or a few hours at the furthest, just as any other soft-bodied insect, but the mature scale does not usually exhibit the effects of the wash or gas for some time. Little can be judged, ordinarily, of the ultimate results before two weeks, and it is often necessary to wait one or even two months to get final conclusions. In the case of liquid washes the slow progressive death of the scales is apparently due to the gradual penetration of the insecticide, and also to the softening and loosening of the scale itself, enabling subsequent weather conditions of moisture and cold to be more fatal.

With such biting insects as caterpillars and slug worms after treatment with arsenicals or other poisons death rapidly follows, the time being somewhat in proportion to the size of the larvæ and their natural vigor. Soft-bodied larvæ, such as the slug worms and very young

larvæ of moths and beetles or other insects, are killed in a day or two. Large and strong larvæ sometimes survive the effect of poison for eight or ten days, and leaf-feeding beetles will often fly away and perish from the poison in their places of concealment.

Many larvæ or other forms of leaf-feeding insects, after taking one or two meals of poisoned foliage, will remain in a semitorpid and diseased condition on the plants for several days before they finally succumb. The protection to the plant, however, is just as great as though they had died immediately, but misapprehension may often arise and the poison may be deemed to have been of no service.

The complete extermination of insects on plants is often a very difficult, if not an impossible, undertaking. This is especially true of scale insects. In California even, where the work against these enemies of fruits has been most thorough and successful, experience has shown that the best that can be done is a practical elimination of the scale for the time being, and it is often necessary to repeat the treatment every year or two. In exceptional cases once in three years suffices. With leaf-feeding insects it is often possible to effect complete extermination with the use of arsenical poisons. Such sucking insects as plant-lice may also be completely exterminated. But in general all applications or methods of treatment must be recognized, more or less, as a continuous charge on the crop, as much so as are the ordinary cultural operations.

CONTROL OF INSECTS BY CULTURAL METHODS.

It is much easier to ward off an attack of insects or to make conditions unfavorable for their multiplication than to destroy them after they are once in possession; and in controlling them, methods and systems of farm and orchard culture have long been recognized as of the greatest value, more so even than the employment of insecticides, which, in most cases, can only stop an injury already begun. Insects thrive on neglect, multiply best in land seldom or never cultivated, and winter over in rubbish, prunings, or the undisturbed soil about their food plants, and become, under these conditions, more numerous every year. It is a fact of common observation that it is the neglected farm, vineyard, or orchard filled with weeds or wild growth which is certain to be stocked with all the principal insect enemies; and, on the other hand, thorough and constant culture, with the removal and burning of prunings, stubble, and other waste, the collection and destruction of fallen and diseased fruit, and the practice, where possible, of fall plowing to disturb the hibernating quarters of field insects, will almost certainly be accompanied by comparative immunity from insect pests.

The vigor and healthfulness of plant growth has also much to do with freedom from insect injury, such plants seeming to have a native power of resistance which renders them, in a measure, distasteful to

most insects, or at least able to throw off or withstand their attacks. A plant already weakened, however, or of lessened vitality from any cause, seems to be especially sought after, is almost sure to be the first affected, and furnishes a starting point for general infestation. Anything, therefore, which aids good culture in keeping plants strong and vigorous, such as the judicious use of fertilizers, will materially assist in preventing injury.

To the constant cropping of large areas of land year after year to the same staple is largely due the excessive loss from insects in this country as compared with European countries, because this practice furnishes the best possible conditions for the multiplication of the enemies of such crops. A most valuable cultural means, therefore, is a system of rotation of crops which will prevent the gradual yearly increase of the enemies of any particular staple by the substitution every year or two of other cultures not subject to the attacks of the insect enemies of the first.

With such insects as the Hessian fly, the squash borers, and many others which have regular times of appearance, much can be done, also, by the planting of early or late varieties, or by deferring seeding so as to avoid the periods of excessive danger. Wherever possible, varieties should be selected which experience has shown to be resistant to insect attack. Familiar illustrations of such resistant varieties in all classes of cultivated plants will occur to every practical man, and a better instance of the benefit to be derived from taking advantage of this knowledge can not be given than the almost universal adoption of resistant American vines as stocks for the regeneration of the vineyards of France destroyed by the phylloxera and for the similarly affected vineyards of European grapes in California.

In the case of stored grain pests, particularly the Angoumois moth, or so-called fly weevil, the chief danger in the South is while the grain is standing in shock or stack, after harvesting, during which period the insects have easy access to it. This source of infestation may be avoided by promptly thrashing grain after harvesting and storing it in bulk. This will prevent the injury of more than the surface layer, as the insects are not likely to penetrate deeply into the mass of the grain.

These general notes are by no means new, but their importance justifies their repetition, as indicating the best preventive measures in connection with the remedial ones already given.

THE PROFIT IN REMEDIAL MEASURES.

The overwhelming experience of the past dozen years makes it almost unnecessary to urge, on the ground of pecuniary returns, the adoption of the measures recommended in the foregoing pages against insects. To emphasize the value of such practice it is only necessary

to call attention to the fact that the loss to orchard, garden, and farm crops frequently amounts to from 15 to 75 per cent of the entire product, and innumerable instances could be pointed out where such loss has been sustained year after year, while now, by the adoption of remedial measures, large yields are regularly secured with an insignificant expenditure for treatment. It has been established that in the case of the apple crop spraying will protect from 50 to 75 per cent of the fruit which would otherwise be wormy, and that in actual marketing experience the price has been enhanced from $1 to $2.50 per barrel, and this at a cost of only about 10 cents per tree for labor and material. This is especially true of regions where the codling moth has but one fall brood annually.

In the case of one orchard in Virginia, only one-third of which was sprayed, the result was an increase in the yield of sound fruit in the portion treated of nearly 50 per cent, and an increase of the value of this fruit over the rest of 100 per cent. The loss from not having treated the other two-thirds was estimated at $2,500. The saving to the plum crop and other small fruits frequently amounts to the securing of a perfect crop where otherwise no yield whatever of sound fruit could be secured.

An illustration in the case of field insects may also be given where, by the adoption of a system of rotation, in which oats were made to alternate with corn, the owner of a large farm in Indiana made a saving of $10,000 per year, this amount representing the loss previously sustained annually from the corn root-worm. The cotton crop, which formerly in years of bad infestation by the leaf-worm was estimated to be injured to the extent of $30,000,000, is now comparatively free from such injury owing to the general use of arsenicals.

Facts of like import could be adduced in regard to many other leading staples, but the foregoing are sufficient to emphasize the money value of intelligent action against insect enemies, which, with the present competition and diminishing prices, may represent the difference between a profit and a loss in agricultural operations.

16871—No. 127—01——4

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

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